Pioneer Venus 1978 Mission Support

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The DSN Master Schedule for preparations for the Pioneer Venus 1978 Mission is updated and the current support status for the mission described.

I. Introduction

The DSN Major Milestone Schedule for Pioneer Venus was originally presented in Ref. 1, and the portion of the schedule dealing with the Differential Long Baseline Interferometry (DLBI) experiment was updated in Ref. 2. The following article brings those schedules and the DSN support status for Pioneer Venus up to date as of June 3, 1977.

In general, at the time of writing of this article, the DSN implementation required for support of Pioneer Venus is in the fabrication stage with essentially all detail design work completed.

II. DSN Major Milestone Schedule for the Orbiter and Multiprobe

The following status information relates to Fig. 1, one of the three schedules accompanying this article. Although no officially signed Support Instrumentation Requirements Document (SIRD) for Pioneer Venus has been received, a preliminary unsigned version of the NASA Support Plan (NSP) was released in mid-April 1977 in order to desseminate current DSN plans and agreements with the Pioneer Project. The unsigned NSP is consistent with DSN implementation and budgetary plans.

The first stage of DSN spacecraft compatibility testing was completed in what is called the weak signal level tests which were conducted at CTA 21 using breadboard spacecraft RF subsystems and a Project-provided telemetry emulator. The tests were in general successful with no problems discovered in the RF area; however, a spacecraft encoder problem was isolated. The encoder problem involved resetting the state of the encoder seven bits later than the end of the fixed sync word in the telemetry frame. The extra bits included the higher-order bits of the subcomm ID word, which is an indexing counter, and therefore the reset was at such a point that the encoder was never reset to a known state. Hughes Aircraft personnel participating in the testing were able to rewire the telemetry emulator in order to put the reset in the proper location. It was subsequently determined that the encoder in the telemetry emulator was identical to that in the Orbiter and Bus spacecraft. Having made special analog recordings of output from an actual probe, Hughes Aircraft brought a recorder to CTA 21 and successfully demonstrated that the encoders on the Probes were indeed correct.

A major objective of the Weak Signal Level Compatibility Testing was the demonstration of coded data telemetry thresholds. Although it was thought at the time of the tests that predicted telemetry thresholds were either met or exceeded in the test conditions for each bit rate, subsequent analysis of the

test data showed that the minimum thresholds, in terms of energy per bit to noise ratio, may have been between 1-1/2 to 3 dB above theoretical values. At this time, it is not known whether the losses experienced were due to the test configurations or some problem with CTA 21 equipment/software. The latter is currently the prime suspect. The plan is now to do self-testing of the DSN equipment within CTA 21 to determine measured values of the telemetry threshold for sequentially decoded data.

The Mark III/DSN Data Subsystems Project has been proceeding generally satisfactorily. DSS 14 may return to operations (here defined as starting the support of mission-dependent testing) on the order of one week late compared to plan because of unanticipated problems in the installation and associated systems performance testing. It will be necessary to extend the downtime schedule of the two conjoint stations (DSS 42-43 and DSS 61-63) two or three weeks because of the experience at DSS 14 coupled with a re-evaluation of the work required at those stations. It is not anticipated that these slips in the MDS Project will have any impact on Pioneer Venus since the completion date for each station is well ahead of Pioneer Venus need dates. The telemetry and command software for Pioneer Venus was available for supporting the Weak Signal Level Compatibility Tests and has subsequently completed formal transfer to operations minus the dual sequentially decoding capability. That means that the telemetry and command software required for support of the launch and the entire Orbiter Mission is already in the hands of operations. Dual sequentially decoding capability is only required for Multiprobe entry and will be utilized to handle the four probes' telemetry data at a single station simultaneously. This is a change from the original plan, which was to produce a Symbol Synchronizer Assembly recording of symbols for two streams out of the four in real-time because of the restriction of having only two Telemetry Processor Assemblies per station. The implementing organization felt that it would be possible to take advantage of the 5-times-faster decoding capability of the TPA compared to the old Digital Data Assembly in order to handle two low-rate streams simultaneously with no significant loss of performance.

A recent addition to Pioneer Venus requirements is the radio metric Intermediate Data Record. Implementation by the DSN of error-detection correction for high-speed data transmission required implementation of new high-speed data formats which involve a 22-bit error code. It was negotiated with Ames Research Center from the beginning that the entire Pioneer Venus Mission would be flown with the new high-speed data formats to avoid a required change in high-speed data formats during the mission. Subsequent to this agreement, it was discovered that there was an incompatibility between the agreed dates for converting to the 22-bit error

code high-speed data formats for Pioneer Venus and the Mission Computing and Control Center (MCCC) schedule for converting to the new format. Although MCCC is not involved in the telemetry and command processing for Pioneer Venus, it is involved in the existing Navigation interface, where radio metric data currently flows through the MCCC 360/75 computer before passing to the Navigation 1108 computers. MCCC does not intend to implement the new high-speed data formats in the 360/75 but rather intends to wait until the implementation of the minicomputers which replace the 360/75 real-time functions. This is planned for May or later in 1978 and also involves a new radio metric interface by which the DSN provides radio metric data directly to the Navigation Team in the form of Intermediate Data Records produced by the Ground Communications Facility of the Deep Space Network.

Pioneer Venus Orbiter launch is in May 1978 and clearly the MCCC May schedule for accommodating 22-bit error code high-speed data formats is incompatible with the Pioneer Venus requirement to have those formats fully operational by February 1, 1978, and available for support of testing by October 1, 1977. This problem was solved by negotiating an earlier date for the availability of the new direct DSN Navigation interface. It is now planned to have both the 22-bit error code high-speed data formats and the radio metric Intermediate Data Record capability available for support of engineering-level tests by October 1, 1977, and fully operational for all Pioneers (including 6 through 11) by February 1, 1978.

Pioneer Venus Orbiter will utilize a new occultation support subsystem at the tracking stations. This subsystem will involve the use of computer-controlled programmable oscillators driving the first LO in the open-loop receivers, which will enable operating the open-loop receivers at a much narrower bandwidth than for previous missions. This narrower bandwidth output from the open-loop receivers (the design goal is for 1-kHz bandwidth at S-band) will be digitized in real-time and recorded on computer-compatible tapes using a dedicated MODCOMP minicomputer. The programmable oscillators will be driven using predicts, which include a prediction of the atmospheric effects of Venus. It is intended that the computer-compatible recordings will be replayed in non-real-time over high-speed data lines back to JPL for production of an Intermediate Data Record for radio science as a deliverable to the experimenters. A backup capability will be provided for shipping the tapes to JPL for direct tape conversion to the IDR format. Detail design is essentially complete on both the hardware and software of this subassembly.

Integration contractor support was desired for the implementation of the occultation support subsystem, and initial problems in negotiating the contract with the vendor, due to

excessive costs, in the first part of calendar 1977 were resolved by delaying some hardware until FY'78 and pulling some of the work back in-house. Secondary requirements for support of the radio science experiments (excluding the DLBI experiment) are the only significant open area in the requirements vs commitments between the DSN and the Pioneer Project. The most serious open area is the question of providing a wider bandwidth backup to the new occultation support subsystem because of experimenter concerns with this new method of supporting occultations and also because as much as the first month of occultations may be visible from only a single DSS. There are other secondary issues such as what data would be available and where the experimenters could view it in real-time during the mission. Many of these issues are being handled on a multimission basis because of similar requirements for the Voyager mission.

As for Near-Earth support for Pioneer Venus, a major decision was reached in deciding that Vanguard support, because of cost vs benefit for the Pioneer Venus launches, has been designated as a desirable but not mandatory requirement, and the Vanguard support has been deleted by the Office of Tracking and Data Acquisition. The deletion of Vanguard has caused the Project to require real-time telemetry and command capability from the STDN station on Ascension Island. The details of the command capability are currently under direct negotiation between Goddard and the Project. The telemetry will be provided via MIL-71 for formatting. The Command System will most likely consist of prerecorded cassette tapes located at Ascension with voice instructions from the Project for their use.

III. Multiprobe Telemetry Recovery Status

Figure 2 portrays the progress for preparing for the Multiprobe telemetry recovery. The extra open- and closed-loop receivers required are well on plan at the current time. The new analog recorders for the precarrier detection telemetry recovery are on plan, and testing to date indicates that the ≲1.5 dB additional loss specification on the precarrier detection recording will be easily met. During the first part of CY'77, some question was raised as to whether the purchase of brand-new Honeywell 96 recorders to meet this requirement was the most cost-effective approach for NASA, and a possible approach of utilizing existing available recorders and borrowing additional recorders from the JPL Loan Pool was investigated. The available recorders' performance compared to Honeywell 96's for this particular application was shown to involve potential additional losses, particularly with mixing of different types of recorders for record and playback, and therefore it was decided that the Honeywell 96's were the proper approach for support of Pioneer Venus. A new requirement related to the precarrier detection recordings is for providing a capability to play the recordings backwards and record the backward symbol output of the Symbol Synchronizer Assembly (SSA). Preliminary testing indicates that such a reverse playback will be feasible with the Honeywell 96 recorders with no appreciable additional loss. This requirement will require some special software for the Telemetry Processor Assembly in order to make the computer-compatible recordings of the output of the SSA. The purpose of this requirement is to attempt to recover the data that will be lost every time the DSN has to reacquire a particular Probe signal.

DSN acquisition involves the sequential acquisition of the receiver, Subcarrier Demodulator Assembly (SDA), Symbol Synchronizer Assembly, and the sequential decoder within the Telemetry Processor Assembly before usable data is produced. This sequential acquisition will take a minimum of two to three minutes (and potentially much longer) every time a receiver is out of lock and has to be reacquired. With the backward playback capability, it should be possible to go several minutes after each receiver out-of-lock and start playing data backwards so the sequential acquisitions of the receiver, SDA, and SSA are completed during a time of good forward data, and then data can be maintained in-lock up to the time of receiver acquisition. The Project will have to provide a capability for decoding the backward symbol stream recordings.

The Multiprobe entry simulator is proceeding well on plan and should provide an excellent capability for operator training for the Multiprobe Mission entry event. For more details on this device, consult Ref. 3.

The functional design of the Signal Presence Indicator (renamed the Spectral Signal Indicator) has been completed. The concept calls for procurement of three commercial 300-kHz bandwidth capability spectrum analyzers per station. A switching matrix will be provided which will enable hooking up any one of the analyzers with any one of the four open-loop receivers or to the output of the DLBI receiver or to a read-after-write of the DLBI recorder. The system will also include a microcontroller and two low-speed printers as well as CRT displays. It is intended that the microcontroller will enable preloading all of the different synthesizer settings both in the open- and closed-loop receivers so that the cursor on the spectrum analyzer can be used to locate the signal of interest and the microcontroller will do all the computations necessary to convert that detected signal into the proper frequency input for a closed-loop receiver operator. The microcontroller may also incorporate an acquisition-aiding feature such as an automatic narrower bandwidth scan of the 300-kHz region of interest.

As far as achieving total readiness for the Multiprobe entry event, the basic plan is to have established the Multiprobe

entry configuration by March 1978 to be followed by two months of procedure development utilizing the complete configurations at DSS 14 and 43. This procedure development is expected to involve utilizing both JPL and station expertise. A procedure verification period will then follow between the Orbiter launch and the Multiprobe launch where although operational proficiency will not be expected, the entry sequence will be exercised in order to verify the validity of the operational concept and procedures. Multiprobe entry testing and training for the purpose of developing operational proficiency will then commence after the Multiprobe launch up to the time of Multiprobe entry.

IV. DLBI Wind Measurement Status

Figure 3 updates the schedule contained in Ref. 2. Only significant changes in plans from that reported in Ref. 2 will be described below. The DSN receiver and calibrator work has been proceeding well and according to plan. STDN detailed receiver design involved the use of modules identical to those of the DSN receiver. The STDN therefore negotiated for the DSN to procure or fabricate the common modules, and funds were transferred from Goddard to JPL for that purpose. It is planned to provide the first set of DSN modules to Goddard on July 1 and the remaining sets on August 1, 1977. It is still intended to do a DSN-STDN equipment integration test utilizing the STDN station at Goldstone from mid-November to mid-December 1977.

Significant changes in the recorder were required because of cost problems which developed in negotiating the contract with the vendor for the operational units. The cost problems were solved by eliminating the microcontroller from the recorders, eliminating some desired multimission capabilities including the deletion of one bit A-to-D required for VLBI purposes, and the delay of one transport each for DSS 14 and 43 to FY'78. The result will be more complexity for the operators, but there has been no loss of the required fundamental capabilities for the Pioneer Venus DLBI Wind Experiment. Delay of one transport each for DSS 14 and 43 to about April 1978 will mean that initial testing will not have redundant recorders available in case of equipment failure.

The bandwidth reduction hardware and software is proceeding satisfactorily and again cost problems had to be solved in the first part of 1977 due to excessive costs proposals from the integration contractor. These cost problems were solved by renegotiation of certain details of the contract and by pulling some of the work back in-house. Detailed format of the deliverable computer-compatible recording out of the bandwidth reduction assembly is now under negotiation between the experimenter and JPL.

It is still intended to start total system checkout from end to end by tracking of ALSEP packages as each station comes on line, starting in February 1978.

There will be a major review of the end-to-end DLBI experiment and equipment in August at the Massachusetts Institute of Technology, with the Review Board comprised of the Project Manager and certain recognized experts across the country who are not directly involved with the experiment.

References

1. Miller, R. B., "Pioneer Venus 1978 Mission Support," in *The Deep Space Network Progress Report 42-32*, pp. 25-30, Jet Propulsion Laboratory, Pasadena, California, April 15, 1976.

2. Miller, R. B., "Pioneer Venus 1978 Mission Support," in *The Deep Space Network Progress Report 42-36*, pp. 22-27, Jet Propulsion Laboratory, Pasadena, California, December 15, 1976.

3. Friedenberg, S. E., "Pioneer Venus 1978 Multiprobe Spacecraft Simulator," in *The Deep Space Network Progress Report 42-38*, pp. 148-151, Jet Propulsion Laboratory, Pasadena, California, April 15, 1977.

MILESTONES

	1976	1977	1978
1	SIRD PRELIMINARY OCTOBER 1975		
2	NSP (SIGNED SIRD PLUS 3 MONTHS)	UNSIGNED	
3	MISSION EVENTS		LAUNCH / MP / ENC
4	DSN-SPACECRAFT COMPATIBILITY TEST CTA 21	MP	
5	GDS COMPATIBILITY ESTABLISHED	WEAK SIGNAL ▪ STRONG SIGNAL OR	
6	DSN LAUNCH READINESS	ONE STATION ▽	▽ THREE STATIONS
7	NEAR-EARTH READINESS		OR▽ MP▽
8	GDS LAUNCH READINESS		OR▽ MP▽
9	LAUNCH OPERATION READINESS TESTING		OR▽ MP▽
10	DSN ENCOUNTER READINESS		(1)▽
11	GDS ENCOUNTER READINESS		
12	DSN 920 COMPUTER REPLACEMENT	TBS / CTA 21 O▶ DSS 12 / O DSS 62 / O DSS 44 / DSS 14 / O DSS 43 / DSS 63 / O DSS 11 / O	
13	DSN TELEMETRY AND COMMAND SOFTWARE	PRELIM ▶ OR ▶ MP▽	
14	DSS 12 S-X-BAND IMPLEMENTATION		O
15	RADIO METRIC INTERMEDIATE DATA RECORD	(1)▽ (1)▽ O▽	
16	HIGH-SPEED DATA FORMATS CHANGE TO 22 BIT ERROR CODE	PRELIM D▽ D▽ (1)▽ (2) (3) (4) P▽ M▽ M▽ M▽	
17	OCCULTATION SUPPORT HARDWARE	PRELIM D▽ SDD▽ SSD▽ SSD▽ O▽	
18	SOFTWARE		S▽ 14 43 O▽▽ ▽63
19	INTEGRATION		
20			

OR = ORBITER
MP = MULTIPROBE
D = DESIGN
P = PROCUREMENT
M = MANUFACTURING OR FABRICATION

O = ENGINEERING TO OPERATIONS TRANSFER
S = SHIP
I = INSTALLATION
T = TESTING

NOTES: (1) CAPABILITY AVAILABLE TO SUPPORT ENGINEERING LEVEL TESTS
(2) JPL DESIGNED HARDWARE
(3) MODCOMP COMPUTERS
(4) COMPUTER TAPE RECORDERS

Fig. 1. DSN major milestone schedule: Pioneer Venus 1978 Orbiter and Multiprobe

	MILESTONES
1	OPEN LOOP RECEIVERS
2	INSTALLATION DSS 14 AND 43
3	5th CLOSED LOOP RECEIVER
4	ANALOG RECORDER TELEMETRY; PROTOTYPE
5	OPERATIONAL DSS 14,43
6	MULTIPROBE ENTRY SIMULATION
7	SIGNAL PRESENCE INDICATOR
8	PROCEDURE DEVELOPMENT TESTING
9	PROCEDURE VERIFICATION TESTING
10	OPERATIONAL PROFICIENCY TESTING
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Years across top: 1976, 1977, 1978 (months J F M A M J J A S O N D)

D = DESIGN
P = PROCUREMENT
M = MANUFACTURING OR FABRICATION
O = ENGINEERING TO OPERATIONS TRANSFER

S = SHIP
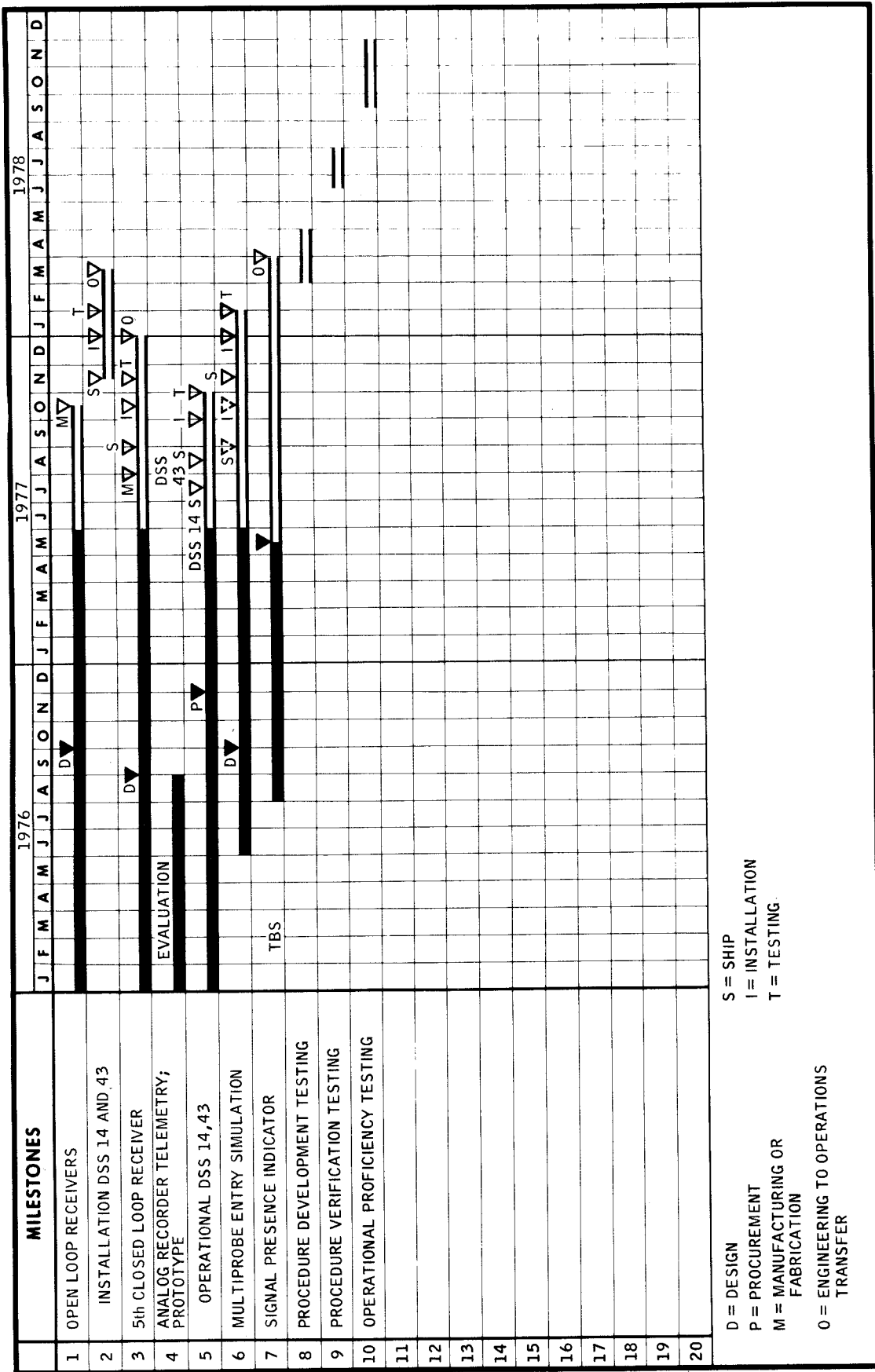I = INSTALLATION
T = TESTING

Fig. 2. DSN major milestone schedule: Pioneer Venus 1978 Multiprobe telemetry recovery

Fig. 3. DSN major milestone schedule: Pioneer Venus 1978 Multiprobe DLBI Wind Measurement Experiment